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Docket No.: 2328-053

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of

Tuqiang NI

U.S. Patent Application No. 09/821,753 : Group Art Unit: 1763

Filed: March 30, 2001 : Examiner: Luz L. ALEJANDRO MULERO

For: PLASMA PROCESSING METHOD AND APPARATUS WITH CONTROL OF PLASMA EXCITATION POWER

TRANSMITTAL OF APPEAL BRIEF

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Submitted herewith is an Appeal Brief in support of the Notice of Appeal filed. A credit card authorization form is attached.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 07-1337 and please credit any excess fees to such deposit account.

Kindly use the attorneys' address associated with the following Customer Number for future correspondence.

Respectfully submitted,

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Allan M. Lowe

Docket No. 2328-053 PATENT

THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of	
Inventors: Tuqiang NI et al.	: Confirmation No. 5171
	:
U.S. Patent Application No. 09/821,753	: Group Art Unit: 1763
	:
Filed: March 30, 2001	: Examiner: Luz L. ALEJANDRO MULERO
For: Plasma Processing Method and Apparatus with Control of Plasma Excitation Power	

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Attn: BOARD OF PATENT APPEALS AND INTERFERENCES

BRIEF ON APPEAL

Further to the Notice of Appeal filed November 21, 2007, in connection with the above-identified application on appeal, herewith is Appellant's Brief on Appeal. The $510 statutory fee is enclosed herewith.

To the extent necessary, Appellant hereby requests any required extension of time under 37 C.F.R. §1.136 and hereby authorizes the Commissioner to charge any required fees not otherwise provided for to Deposit Account No. 07-1337.

01/23/2008 VBUI11 00000056 09821753
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TABLE OF AUTHORITIES

Cases

I. Real Party in Interest

The real party in interest is Lam Research Corporation, a Calfornia corporation.

II. Related Appeals and Interferences

There are no related appeals and/or interferences.

III. Status of Claims

A. Total Number of Claims in Application

1. There are 66 claims in the application, identified as claims 1-66.

B. Status of all the claims

1. Claims canceled: 1-37
2. Claims withdrawn from consideration but not canceled: None
3. Claims pending: 38-66
4. Claims allowed: None
5. Claims rejected: 38-66

C. Claims on Appeal: 38-66

IV. Status of Amendments

All amendments have been entered. There was no amendment after final rejection.

V. Summary of Claimed Subject Matter

Claim 42 is directed to a method of forming a rounded corner 216 (Figure 6; page 16, line 24; page 5, line 28) of a trench of a workpiece in the form of silicon substrate 202 (Figure 5; page 15, line 2) in vacuum plasma chamber 40 (Figure 1;

page 7, lines 3 and 4; page 1, lines 2-5). A gas species, particularly a mixture of HBr/O2 (page 16, line 29-page 17, line 1) that is supplied to chamber 40, is converted (page 7, line 29-page 8, line 3) into an etchant plasma that is continuously applied to workpiece 202 while rounded corner 216 is being formed (page 16, line 23-page 17, line 1). While rounded corner 206 is being formed, the power applied to the etchant plasma is gradually changed (page 17, lines 1-4). The gradual changes are such that the power applied to the etchant while rounded corner 206 is being formed does not remain constant for durations in excess of one second (page 6, lines 9 and 10; page 13, lines 13-16). The inventors have found that steps lasting longer than about one second do not have adequate temporal resolution to achieve the desired workpiece shapes (page 6, lines 9 and 10). While rounded corner 206 is being formed, the mixture of HBr/O2 constantly flows into chamber 40 (page 16, line 29-page 17, Line 1) so the flow rate of the gas species into chamber 40 and the species flowing into chamber 40 are maintained constant while the rounded corner is being formed.

Independent claim 47 is concerned with a method of etching workpiece 202 (Figure 5; page 15, line 2) in vacuum plasma processor chamber 40 (Figure 1; page 7, lines 3 and 4). A gas species in the form of HBr/O2 (page 16, line 29-page 17, line 1) is converted into an AC etchant plasma (page 1, line 4; page 15, line 16 and 26) that is applied to workpiece 202 while a desired shape (page 6, line 14), in the form of rounded corner 216 (Figure 6) of workpiece 202, is being formed. The AC etchant plasma is always the dominant material applied to the workpiece while the desired shape is being formed (page 5, lines 26-28; claim 8, page 19 of the application as filed; page 16, line 23-page 17, line 2; page 17, lines 4-6). In this regard, item 3 of the Bailey May 17, 2007 Declaration indicates why these portions of the application cause one of ordinary skill in the art to realize the AC etchant plasma is always the dominant material applied to the workpiece while the desired shape as being formed. Vacuum chamber 40 is subject to operating at different pressures while workpiece 202 is being processed (page 9, lines 3-5), and the gas species can flow at different flow rates into chamber 40 while workpiece 202 is being processed (page 8, lines 23-25). The

amount of AC power supplied to the plasma during etching of workpiece 202 to form the desired shape rounded corner 216 gradually changes on a pre-programmed basis (page 10, lines 7-15; page 11, lines 12-16; page 11, line 23-page 12, line 2; page 12, line 25-page 13, line 5; page 14, lines 7-9). A gradual transition in the shape of material that has the desired rounded corner shape in workpiece 202 being processed occurs in response to the gradual power change (page 16, line 21-page 17, line 2). The gradual power change occurs during the gradual transition in the shape of the material that has the rounded corner desired shape (page 16, line 21-page 17, line 2).

Independent claim 59 is directed to a memory 24 (Figure 1) storing a computer program for controlling a computer for controlling etching of workpiece 202 in vacuum plasma processor chamber 40 (page 7, lines 15-20; page 12, lines 8, 9 and 25-28). Claim 59 indicates the memory causes the computer to control etching of workpiece 202 to perform the same steps as defined by claim 47.

Claim 40, dependent on claim 42, indicates the gradual change includes steps having power changes no greater than several watts, indicated as being 15 watts in the specification (page 6, line 6; page 13, line 13).

Claims 41 and 55, respectively dependent on claims 40 and 54, in turn dependent on claim 49 which is ultimately dependent on claim 47, state the power steps are a few milliwatts, indicated as being 6.667 milliwatts in the specification, and remain at a constant power for about 1 millisecond (page 17, line 4).

Claims 46 and 56, respectively dependent on claims 40 and 54, indicate an electric source, in the form of variable gain power amplifier 132 of circuit 14 that applies RF to electrode 56 (Figure 1; page 11, lines 12-16; page 12, lines 18-24)

applies the gradually changing power to the etchant plasma in steps having a maximum change of less than 5% of the source maximum output power (page 13, lines 10 and 11; page 6, lines 4 and 5). The inventors found steps having power changes greater than about 5% of the maximum output power are too steep to provide the desired control over the plasma to achieve the desired workpiece shapes (page 6, lines 7-9).

Claims 48 and 60, respectively dependent on claims 47 and 59, indicate the etchant plasma is continuously applied to workpiece 202 while the desired rounded corner shape 216 is being formed (page 16, line 29-page 17, line 1).

Claims 49 and 61, respectively dependent on claims 48 and 60, indicate the gradual power change occurs while no change is made in the species, pressure or flow rate of the gas species that is converted into the AC etchant plasma applied to workpiece 202 to form the desired, rounded corner shape 216 (page 16, lines 28 and 29).

Claims 50 and 62, respectively dependent on claims 48 and 60, indicate the desired shape is a curved surface, which in the specific embodiment is rounded corner 216 (Figure 6; page 16, line 24). The rounded corner is specifically set forth in claims 51 and 63, respectively dependent on claims 50 and 62 (page 16, lines 21-25). Claims 52 and 64, respectively dependent on claims 51 and 63, indicate rounded corner 216 is at an intersection of a wall and base 214 of the trench illustrated in Figure 6.

Claim 53 indicates the curved surface of claim 50 is rounded corner 216 that is at an intersection of a wall and a surface, in the form of the base 214 that intersects

the wall, wherein the surface 214 extends generally at a right angle to the wall (Figure 6).

Claim 54 states the gradual change of claim 49 includes steps having power changes no greater than about several watts (indicated as 15 watts at page 6, line 6 and page 13, line 13), wherein the power remains constant at a wattage for no more than about one second (page 6, lines 9 and 10; page 6, line 6; page 17, line 4).

Claims 57 and 65, respectively dependent on claims 48 and 62, indicate the gradual power change includes steps having power changes in the range of a few milliwatts to several watts and durations in the range of about 1 millisecond to no more than one second (page 6, lines 4-10).

Claims 58 and 66, respectively dependent on claims 50 and 60, require the gradual change to include steps having power changes no greater than about several watts (specifically 15 watts), and the power to remain at a constant wattage for no more than about second (page 6, lines 4-10).

VI. Grounds of Rejection to be Reviewed on Appeal

A. The specification provides support for the requirement of claims 47 and 59 for "the AC etchant plasma always being the dominant material applied to the workpiece while the desired shape is being formed."

B. The obviousness rejection of independent claim 42, and claims 38-41 and 43-46 which depend on claim 42, based on Chao et al., US patent publication 2002/0106845 is wrong.

C. The obviousness rejection of independent claims 47 and 59, and claims 48-58 and 60-66 which depend on claims 47 and 59, based on Bhardwaj et al., US patent 6,051,503, and Howald et al., WO 00/58992 is wrong.

VII. Argument

A. The specification provides support for the requirement of claims 47 and 59 for "the AC etchant plasma always being the dominant material applied to the workpiece while the desired shape is being formed."

Page 16, line 23-page 17, line 2 states microprocessor 201 has a memory system that performs a final etch operation for 15 seconds. This portion of the specification indicates the final etch operation causes formation of rounded edge, i.e. corner, 216 between point 212 and base 214, Figure 6. It also states that during the 15 second final etch operation, a suitable mixture of HBr/O_2 constantly flows from source 68 into chamber 40 while the power which amplifier 132 supplies to electrode 56 gradually changes from 200 watts to 100 watts in 15,000 steps, each having a duration of 1 millisecond and an amplitude of 6.667 milliwatts.

Andrew D. Bailey, Ph.D., who qualifies as an expert in the field because of his education and work experience and is one who is familiar with those of ordinary skill in the art because of his work experience, has testified about this issue in item 3, pages 2-4 of his June 5, 2006 Declaration and in item 3, pages 2 and 3 of his May 17, 2007

Declaration. Dr. Bailey has testified that one of ordinary skill in the art would interpret the statement on page 16, line 23-page 17, line 2 to mean that the etchant HBr is always dominant over the O_2 passivation gas while roundeed corner 216 is being formed because the final etch operation occurs during the 15 second etch period. Dr. Bailey has testified that one of ordinary skill in the art knows that if the etchant gas HBr and the passivation gas O_2 both constantly flow to a chamber to perform an etch operation, that the etchant gas HBr must always be dominant over the passivation gas O_2. Otherwise, the material in the passivation gas deposited on the workpiece would have a greater effect on the material being worked than the etchant gas and the rounded corner would not have been formed and etching would not occur (May 17, 2007 Declaration, last three sentences of item 3 (b)).

The last sentence in the paragraph that ends in the middle of page 2 of the final rejection states: "Further, it appears that using a deposition gas with an etching gas is taught in paragraph 0030 of the instant application." This statement is irrelevant to the requirement of claims 47 and 59 for the AC etchant plasma to always be the dominant material applied to the workpiece while the desired shape is being formed. Claims 47 and 59 do not indicate the etchant gas is the only gas always applied to the material while the desired shape is being formed. The claims indicate the etchant gas, such as HBr, is dominant over the other gases, for example, the passivation (that is deposition) gas O2.

The second full paragraph on page 8 of the final rejection states "clearly the rounded corners can be formed if the etchant material is not the dominant material 100% of time." The statement is immaterial to appellants' disclosure on page 16, line 29-page 17, line 1 which states that while rounded corner 216 is being formed, the HBr/O2 mixture constantly flows into chamber 40. Because the mixture constantly flows into chamber 40 while rounded corner 216 is being formed, the mixture does not change while the corner is being formed. Because the mixture does not change while the corner is being formed and the corner is formed by etching, the etchant material must be dominant during the corner formation.

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Based on the foregoing, claims 47 and 59 satisfy the requirements of 35 USC 112, paragraph 1. As a result, the claims dependent on claims 47 and 59, that is, claims 48-58 and 60-66, comply with written description requirement of 35 USC 112, paragraph 1.

B. The obviousness rejection of independent claim 42, and claims 38-41 and 43-46 which depend on claim 42, based on Chao et al., US patent publication 2002/0106845 is wrong.

1. The rejection of claim 42 is wrong because Chao et al. does not (a) disclose gradually changing the power applied to etchant plasma while a rounded corner is being formed, and (b) make obvious gradual power changes that do not remain constant for durations in excess of one second while the rounded corner is being formed.

The second full paragraph on page 3 of the final rejection incorrectly relies on paragraphs 0048 and 0049, as well as Figure 4D, of Chao et al. to meet the requirement of claim 42 for the power applied to the etchant plasma to change while a rounded corner is being formed. Paragraphs 0048 and 0049, as well as paragraph 0050, that go into detail about the bottom-corner-rounding (BCR) etch process, have no disclosure of changing power while the corner is being formed. The second sentence of paragraph 0048 indicates the bottom corner at rounding etch process uses primarily a chemical process.

The last sentence of paragraph 0049 is the only relevant portion of paragraphs 0048 and 0049 that mentions power. The last sentence of paragraph 0049 merely states that when there is an increase in the power of source 105 that drives antenna 102, having plural turns to produce RF electromagnetic fields (paragraph 0024), there is an increase in the amount of rounding at the bottom corners. This statement does not say the power of source 105 increases while the corner is being formed. A reasonable interpretation of this statement is that the power of source 105 increases prior to the corner being formed and that such a power increase results in increased corner rounding.

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The foregoing argument was presented to the examiner prior to issuance of the final rejection, but was ignored as indicated by the statement in the third sentence on page 7 of the final rejection which states: "However, the reference clearly discloses the relationship between rounding the trench corners and increasing the power (see paragraph 0049)." This statement is irrelevant because it does not mention the requirement of claim 42 for the gradual change in the power applied to the etchant plasma to occur "while the rounded corner is being formed."

Paragraph 0050 indicates power supply 105 supplies 300 watts of RF power to antenna 102 to ignite the plasma. The reference then goes on to say the source power is lowered to increase the etch uniformity, and that the reduced source power decreases etch rate. The reference also indicates the RF bias power supplied by source 106 to pedestal 107 is reduced to minimize high-speed ion bombardment against substrate 110. Based on the foregoing, there is nothing in any of paragraphs 0048-0050 to indicate power supplied to the etchant plasma is changed while the rounded corner is being formed.

The Tables in paragraphs 0054 and 0055 indicate the power applied by source 105 to antenna 102 during bottom-corner-rounding can be anywhere between 200 to 1500 watts. This does not mean the power is changed during bottom corner rounding, but merely states the power applied to antenna 102 can be within this range during the entire time while the bottom corner rounding occurs.

Based on the foregoing, Chao et al. does not disclose the requirement of independent claim 42 for gradual changes in the power supplied to the etchant plasma to occur while a rounded corner is being formed.

Because Chao et al. does not disclose gradually changing the power supply to the etchant plasma while a rounded corner is being formed, it does not make obvious the requirement of claim 42 for the gradual changes to be such that the power does not remain constant for durations in excess of one second while the rounded corner is being formed. Further, the requirement for the time for the plasma to remain constant

for durations not in excess of one second is an important limitation in forming a rounded corner, as pointed out on page 6, first full paragraph of the application as filed. It is there indicated that steps lasting longer than about one second do not have adequate temporal resolution to achieve the desired workpiece shapes. Chao et al. has no recognition of the importance of minimizing the duration of a gradual power change and the shape of a rounded corner. Consequently, it would not have been obvious to one of ordinary skill in the art at time the invention was made to determine, through routine experimentation, the manner in which the power applied to the etchant plasma is changed while the rounded corner is being formed.

Chao et al. indicates a soft etch is applied to the workpiece after the bottom corner rounding has been completed because the soft etch removes damaged outer surfaces without significantly altering the trench profile or worsening the sidewall roughness; see paragraph 0056. Applicants' claimed method enables rounded corners to be formed without such damage. In this regard, see paragraph 0004 of the Declaration of Thomas A. Kamp. The Kamp Declaration indicates smooth rounded corners of workpiece trenches were formed by the process of claim 42, without damaged edges and without using a soft etch. The soft etch is undesirable because it increases processing time and required resources. These beneficial results are evidence of unobviousness of the process defined by claim 42. If the process defined by claim 42 were obvious from Chao et al., the claimed process would have been incorporated in the bottom-corner-rounding etch process of Chao et al, to avoid the need for a soft etch. The Kamp Declaration provides further evidence of the unobviousness of claim 42 because it indicates the problems of the prior art, set forth in the paragraph bridging pages 2 and 3 and the only full paragraph on page 3 of the application as filed, are overcome by the process of claim 42. The paragraph bridging pages 2 and 3 indicates that sudden changes in at least one of gas flow rate, chamber pressure, or power supplied to a plasma gas species flowing into a chamber result in sharp demarcations between layers etched from a workpiece.

The only full paragraph on page 3 of appellants' specification indicates problems are encountered as a result of transiently adding dilutants and/or passivation

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gases to the processing chamber. Transiently adding dilutants and/or passivation gases is indicated as being disadvantageous because the relatively large volume of a typical plasma processing chamber requires a significant amount of time, up to 10 seconds, to purge "old" gas from a line coupling gas from a gas source into a chamber. As result, there are substantial increases in workpiece processing time, to reduce efficiency and decrease workpiece throughput. In addition, changing the gas species on a transient basis, results in a change in plasma electrical impedance. The plasma impedance change adversely affects the ability of matching network 108 or 138 (Figure 1), between electric source 180 and 30, respectively, and coil 48 and electrode 56, respectively, to provide an efficient transfer of power between the electric source or sources and the driven loads in processing chamber 40. In addition, the time required for a new gas, that is, the dilutant or passivation gas, to flow into the chamber is likely to vary as a function of gas line length between the chamber and the gas source. As a result, precise control of the processing step is difficult to achieve and/or recipe processing steps must be customized for different gas line lengths between the different gas sources and the chamber. The Kamp Declaration indicates these problems are overcome by the process of claim 42. The examiner has essentially ignored this evidence of unobviousness by stating on page 8, last sentence of the final rejection, that the claims do not state that a soft etch is not required after rounding of the trench corners.

Based on the foregoing, the allegations in the office action concerning maintaining the flow rate and species flowing into the chamber constant while power supplied to the plasma is gradually changed to form a rounded corner are wrong.

2. The final rejection has no rationale for the rejection of claims 40, 41 or 46.

The office action fails to consider the limitations of claims 40, 41 and 46, all of which depend on claim 42, either directly or indirectly. Hence, no attempt has been made to establish a *prima facie* case of obviousness with regard to any of claims 40, 41 or 46.

C. The obviousness rejection of independent claims 47 and 59, and claims 48-58 and 60-66, which depend on claims 47 and 59, based on Bhardwaj et al., US patent 6,051,503, and Howald et al., WO 00/58992 is wrong.

1. The final rejection is wrong in alleging Bhardwaj et al. meets the requirement of claims 47 and 59 for AC etchant plasma to be always the dominant material applied to a workpiece while a desired shape of the workpiece is being formed.

The final rejection, in the first sentence of the paragraph bridging pages 4 and 5 thereof, alleges the desired shape of the Bhardwaj et al. workpiece is a portion of the sidewall of the trench. There is no basis in the reference for such a conclusion. In Bhardwaj et al., a desired shape is a wall of a trench, not a portion of a wall of the trench. Column 1, lines 41 and 42, indicates Bhardwaj et al. is concerned with etching a trench in a semiconductor substrate. The examiner points to no portion of the reference to support her position that the desired shape is merely a portion of the trench sidewall.

The opening paragraph of the reference indicates the subject matter of Bhardwaj et al. is concerned with "depositing a sidewall passivation layer on etched features and methods of etching such features including the passivation method (emphasis added)." The second sentence of the next paragraph indicates a passivation layer is formed by a being laid down, that is, by being deposited. In other words, one aspect of Bhardwaj et al. is concerned with depositing a passivation layer on features that have already been etched, and another aspect of the reference is concerned with etching by depositing a passivation layer. Bhardwaj et al. achieves this objective by alternate etching and deposition steps; column 1, lines 41-45.

The examiner apparently presumes that the alternate etching and deposition steps occur along different portions of the trench wall. However, she points to no

portion of the reference to support this position. In fact, the first paragraph of the reference belies this position because it indicates a sidewall passivation layer is deposited on etched features. In addition, the third paragraph of the patent indicates a problem with the prior art is that it employed completely alternate steps. The inference is that the alternate etching and deposition steps of Bhardwaj et al. resolve this problem because the alternate steps occur in the same region along the trench wall. This inference is supported by the time durations of the alternate etch and deposition steps; column 2, line 26 indicates the alternate steps may have periods of less than 7.5 seconds or even 5 seconds; column 6, lines 50-67, indicates the preferred durations of the alternate deposition and etch steps is 4-6 seconds and that the step range is 2-15 seconds. The lengths of these periods appear to be such that the gas which causes deposition cannot be swept out of a particular portion of the trench wall before the etchant gas is applied to that same portion of the wall; see page 3 of appellants' specification that indicates up to 10 seconds are required to purge the line between the gas source and the chamber. In any event, the examiner has the burden of proving, by rationale or evidence, that the gas which causes deposition is necessarily swept out of a particular portion of the trench wall before the etchant gas is applied to that same portion of the wall to support her position that a portion of the sidewall of the trench can be considered as the desired workpiece shape to which a dominant etchant gas is always applied. Ex parte Levy, 17 U.S.P.Q.2d 1461, 1464 (B.P.A.I. 1990); In re Oelrich, 666 F.2d 578, 581-82, 212 U.S.P.Q. 323, 326 (C.C.P.A. 1981); In re Rijckaert, 9 F.3d 1531, 1532, 28 U.S.P.Q.2d 1955, 1956 (Fed. Cir. 1993); In re Robertson F.3d 743, 745, 49 USPQ2d 1949, 1950-51 (Federal Circuit 1999). The examiner has made no attempt to provide such proof or rationale.

The first full paragraph on page 8 of the final rejection states "if the power is gradually changed in the Bhardwaj et al. reference similarly to the claimed invention, then some rounding of the corners inherently will be expected to occur." Firstly, the power is not changed in Bhardwaj et al. similarly to the claimed invention because the reference does not disclose an AC etchant plasma always being the dominant material

applied to the workpiece while the desired shape is being formed, as previously discussed. In addition, this reliance on inherency does not provide proof or rationale to indicate rounded corners are necessarily formed by the Bhardwaj et al. method.

An inspection of the SEMs (scanning electron micrographs) of the reference indicates the Bhardwaj et al. method does not produce rounded corners and the inherency position set forth on page 8 in the final rejection is wrong. The SEM of Figure 10, which possibly shows rounded corners, indicates the shape of a trench made with the process that is prior art to Bhardwaj et al.; the SEM of Figure 16 is also prior art to Bhardwaj et al.. The SEMs of Figures 12, 14, 17 and 18 indicate the intersection of the walls and bases of the trenches produced by the Bhardwaj et al. process do not have rounded corners.

Further evidence that Bhardwaj et al. does not meet the requirement of claims 42 and 59 for the AC etchant plasma to always be the dominant material applied to the workpiece while the desired shape is being formed is found in paragraphs 4 and 5 of the Bailey May 17, 2007 Declaration. It is there indicated that in Bhardwaj et al. the desired shape constitutes the walls of a trench that is formed by repeatedly changing the specie from an etchant gas to a passivation gas. Bailey discusses the advantage of maintaining species constant while a desired shape is being formed, by referring to page 3, lines 3-28 of the specification of appellants' application. He also indicates the method of the present invention avoids the problems of the prior art that Bhardwaj et al. were trying to overcome, without the problems associated with alternately supplying etchant and passivation gases to the workpiece.

2. The features of dependent claims 48-58 and 60-66 are not disclosed or made obvious by Bhardwaj et al., the only reference relied on by the examiner for the features of these claims.

Claims 48 and 60 require the etchant plasma to be applied to the workpiece while the desired shape as being formed. As discussed supra, in Bhardwaj et al. the etchant plasma and the plasma that causes deposition of the passivation layer are alternately applied to the workpiece while the desired shape is being formed.

Claims 49 and 61 indicate the gradual power change which occurs during etching of the workpiece to form the desired shape occurs while no change is made in the species, the pressure, or the flow rate of the gas species that is converted into the AC etchant plasma. In Bhardwaj et al. there is a change in the gas species because of the alternate flow of the etchant plasma and the plasma that causes deposition of the passivation layer.

Claims 50 and 62 indicate the desired shape that is formed as a result of the gradual power change, the species and the continuous application of the plasma to the workpiece are such that the desired shape is a curved material. Bhardwaj et al. has no disclosure of a curved material being formed and indicates the curved surfaces in the prior art of Figure 11 are overcome as a result of the method disclosed in the reference.

The statement in the last sentence at the top of the paragraph page 5 of the final rejection does not provide adequate rationale to show that Bhardwaj et al. produces a curved material in the form of a rounded profile. This statement says Bhardwaj et al. inherently provides a gradual power change that produces a rounded profile because "the gradual power change in the instant application similarly produces a rounded profile." However, the process defined by appellants' claims is not the same as the process disclosed by Bhardwaj et al., for the reasons discussed above in connection with the independent claims. In addition, the gradual power change disclosed in appellants' application is quite different from any disclosure of gradual power changes in the reference. In this regard, appellants' disclosure indicates: the

maximum duration of the power change is one second; in the preferred embodiment the power change duration is 1 millisecond; the maximum power change is 15 watts; in the preferred embodiment the power change is 6.667 milliwatts. There is no disclosure in the reference of the parameters associated with the gradual changes in the RF bias ramps in Figure 9(i) thereof. Further, the SEMs in Figures 12-14, 17 and 18 of Bhardwaj et al. fail to show a desired curved shape. The foregoing argument is applicable to claims 51 and 63 which indicate the curved surface is a rounded corner.

Claims 52 and 64 require the rounded corner to be at an intersection of a wall and a base of a trench. Claim 53 indicates the rounded corner is at an intersection of a wall and a surface intersecting the wall, wherein the surface extends generally at right angles to the wall. Because Bhardwaj et al. does not disclose a rounded corner, it does not disclose a rounded corner at an intersection of a wall and a base of a trench or at an intersection of a wall and a surface intersecting the wall at right angles to the wall.

The final rejection incorrectly states the requirement of claim 54 for the gradual change to include steps having power changes no greater than about several watts, wherein the power remains constant at a wattage for no more than about one second, would have been obvious to one of ordinary skill in the art of the time the invention was made. The office action alleges these parameters are obvious as a result of routine experimentation to determine the optimum amount of time in which the powers remain constant and the optimum amount the power is to change, to achieve the desired rounded profile of the trench. Firstly, appellants discovered that the power should remain at a constant value for no more than about one second because steps longer than this time do not have adequate temporal resolution to achieve the desired workpiece shapes and that large amplitude step changes, having a maximum change of greater than 5% of the source maximum output power (claim 56 indicates the steps have a maximum change of less than 5% of the source maximum output power) are

excessively steep to provide the desired control over the plasma to achieve the desired workpiece shapes; page 6, lines 3-10 of the application as filed. The examiner points to nothing in the Bhardwaj et al. reference to indicate there was an appreciation of a relationship between desired workpiece shape and the amplitude and/or duration of step changes in the amount of power applied to the plasma while a desired shape is being formed. Consequently; the entire basis for the examiner's position regarding obviousness of these parameters is without foundation. In addition, the particular parameters set forth in claims 54 and 56 are important in achieving the beneficial results set forth in the Kamp Declaration.

Claim 55 indicates the power steps of claim 54 are a few milliwatts and remain at a constant power for about 1 millisecond. Steps of these amplitudes and durations enable the desirous rounded corner results set forth in the Kamp Declaration to be achieved by appellants' method. In Bhardwaj et al., the minimum step duration is stated to be two seconds (column 6, lines 50-67), more than three orders of magnitude greater than 1 millisecond. Hence, the step duration of the prior art relied on by the examiner is a difference in kind from the step duration set forth in claim 55.

Claims 57, 58, 65 and 66 indicate the gradual power change includes steps having constant power for no more than one second. In addition, claims 57 and 65 indicate the steps have changes in the range of a few milliwatts to several watts and claims 58 and 66 require the steps to have power changes no greater than about several watts. As discussed supra, there was no appreciation in the Bhardwaj et al. reference of the advantages associated with the parameters set forth in these claims.

D. Conclusion

Appellants have demonstrated through argument and by the submission of evidence from an expert in the field who is familiar with those of ordinary skill in the art

that one of ordinary skill in the art would understand that there is adequate disclosure for the requirement of for the AC etchant plasma to always be the dominant material applied to the workpiece while the desired shape is being formed. The application as filed indicates a rounded corner is etched by constantly applying a gas mixture including an etchant and a passivation gas to a workpiece. Because the gas is constantly applied, the gas does not change while the rounded corner is being etched. Because the material forming the rounded corner is etched, the etchant must always be dominant over the passivation gas while the rounded corner is being etched.

Chao et al. does not render claim 42 and the claims dependent thereon obvious because, inter alia, the reference not disclose gradually changing the power applied to an etchant plasma while a rounded corner is being formed. Chao et al. merely indicates there is a relationship between the power applied to the plasma and the etching characteristics of the plasma. The disclosure of such a relationship does not mean there is a disclosure of gradually changing the power applied to an etchant plasma while a rounded corner is being formed.

Bhardwaj et al. and Howald do not render claims 47 and 59 obvious because, inter alia, neither reference discloses an AC etchant plasma always being the dominant material applied to a workpiece while a desired shape is being formed while there is a gradual change in the amount of AC power supplied to the plasma during etching of the workpiece to form a desired shape. Further, Bhardwaj et al. does not indicate a desired shape is a curved surface, particularly a rounded corner; the micrographs in the reference do not show such desired shapes. Appellants' specification and the Kamp Declaration indicate the criticality of parameters associated with the duration and amplitude of gradual step changes in the power applied to the plasma while the desired shape is being formed. Neither reference shows an appreciation of any relationship between the parameters associated with the duration

and amplitude of gradual step changes in the power applied to the plasma and the shape of the etched workpiece.

The various rejections are based on conjecture. They are not based on evidence or proper rationale. As a result, they are wrong. Reversal is in order.

Respectfully submitted,

Lawrence WILCOCK et al.

By: Allan M. Lowe

Allan M. Lowe
Reg. No. 19,641

VIII. Claims Appendix

38. The method of claim 42 wherein the rounded corner is at an intersection of a wall of the trench and a base of the trench.

39. The method of claim 42 wherein the rounded corner is at an intersection of a wall of the trench and a surface intersecting the wall, the surface extending generally at right angles to the wall.

40. The method of claim 42 wherein the gradual change includes steps having power changes no greater than about several watts.

41. The method of claim 40 wherein the power steps are a few milliwatts and remain at a constant power for about 1 millisecond.

42. A method of forming a rounded corner of a trench of a workpiece in a vacuum plasma chamber, comprising converting a gas species that is supplied to the chamber into an etchant plasma that is continuously applied to the workpiece while the rounded corner is being formed, gradually changing the power applied to the etchant plasma while the rounded corner is being formed, the gradual changes being such that the power does not remain constant for durations in excess of one second while the rounded corner is being formed, and, while the rounded corner is being formed, maintaining constant: (a) the flow rate of the gas species into the chamber and (b) the species flowing into the chamber.

43. The method of claim 42, wherein the etchant gas is the dominant gas.

44. The method of claim 41, wherein the etchant gas is the dominant gas.

45. The method of claim 42 wherein pressure in the chamber is maintained constant while the rounded corner is being formed.

46. The method of claim 40 wherein an electric source having a maximum output power applies the gradually changing power to the etchant plasma, the steps having a maximum change of less than 5% of the source maximum output power.

47. A method of etching a workpiece in a vacuum plasma processor chamber comprising converting a gas species into an AC etchant plasma that is applied to the workpiece while a desired shape of the workpiece is being formed, the AC etchant plasma always being the dominant material applied to the workpiece while the desired shape is being formed, the vacuum chamber being subject to operating at different pressures while the workpiece is being processed, the gas species being subject to flowing into the chamber at different flow rates while the workpiece is being processed, gradually changing, on a pre-programmed basis, the amount of AC power supplied to the plasma during etching of the workpiece to form the desired shape, wherein a gradual transition in the shape of material that has the desired shape in the workpiece being processed occurs in response to the gradual power change, the gradual power change occurring during the gradual transition in the shape of the material that has the desired shape.

48. The method of claim 47 wherein the etchant plasma is continuously applied to the workpiece while the desired shape is being formed.

49. The method of claim 48 wherein the gradual power change occurs while no change is made in (a) the species, (b) the pressure or (c) the flow rate.

Serial No. 09/821,753

50. The method of claim 48 wherein the species is ionized into a plasma that etches the material to form the desired shape, the gradual power change, the species and the continuous application of the plasma to the workpiece being such that the material is shaped to have a curved surface, the curved surface being formed in response to changes in the ionized plasma etchant resulting from the gradual power change.

51. The method of claim 50 wherein the curved surface is a rounded corner, and the etching, which occurs in response to changes in the ionized plasma etchant resulting from the gradual power change and the continuous application of the plasma to the workpiece, forms a trench wall including the rounded corner, the trench and the rounded corner being included in the desired shape.

52. The method of claim 51 wherein the rounded corner is at an intersection of a wall and a base of a trench.

53. The method of claim 50 wherein the curved surface is a rounded corner at an intersection of a wall and a surface intersecting the wall, the surface extending generally at right angles to the wall.

54. The method of claim 49 wherein the gradual change includes steps having power changes no greater than about several watts, the power remaining at a constant wattage for no more than about 1 second.

55. The method of claim 54 wherein the power steps are a few milliwatts and remain at a constant power for about 1 millisecond.

Serial No. 09/821,753

56. The method of claim 54 wherein an electric source having a maximum output power applies the gradually changing power to the etchant plasma, the steps having a maximum change of less than 5% of the source maximum output power.

57. The method of claim 48 wherein the gradual power change includes steps having power changes in the range of a few milliwatts to several watts and durations in the range of about one millisecond to no more than one second.

58. The method of claim 50 wherein the gradual change includes steps having power changes no greater than about several watts, the power remaining at a constant wattage for no more than about 1 second.

59. A memory storing a computer program for controlling a computer for controlling etching of a workpiece in a vacuum plasma processor chamber wherein a gas species is converted into an AC etchant plasma, the chamber being capable of operating at different pressures while the workpiece is being processed, the gas species being subject to flowing into the chamber at different flow rates while the workpiece is being processed, the computer program storing signals causing (a) control of the amount of AC power applied to the plasma while the workpiece is being etched; (b) the application of the AC etchant plasma to the workpiece while a desired shape of the workpiece is being formed, and (c) the AC etchant plasma to always be the dominant material applied to the workpiece while the desired shape is being formed, the stored signal for controlling the amount of applied AC power causing gradual preprogrammed changes in the amount of AC power supplied to the etchant plasma during etching of the workpiece, the stored signal causing the gradual power change being such as to cause a gradual transition in the shape of material in the workpiece being etched in response to the gradual power change to cause the gradual power change to occur during the gradual transition in the shape of the material.

Serial No. 09/821,753

60. The memory of claim 59 wherein the computer program causes the etchant plasma to be continuously applied to the workpiece while the desired shape is being formed.

61. The memory of claim 60 wherein the computer program also stores signals for causing (a) the vacuum chamber to operate at different pressures while the workpiece is being etched and (b) control of the gas species type and the flow rates thereof into the chamber while the workpiece is being etched, the stored signals causing the gradual power change to occur while no change is made in (a) the species, (b) the pressure or (c) the flow rate.

62. The memory of claim 60 wherein the stored signals control (a) etchant species supplied to the chamber while the workpiece is being processed and (b) the gradual power transition so as to cause the workpiece to be etched so the desired shape is a curved surface.

63. The memory of claim 62 wherein the curved surface is a rounded corner, and the stored signals control (a) etchant species supplied to the chamber while the workpiece is being processed and (b) the gradual power transition so as to cause the workpiece to be etched to have a trench wall including the rounded corner.

64. The memory of claim 63 wherein the rounded corner is at an intersection of a wall and a base of a trench.

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65. The memory of claim 62 wherein the gradual change includes steps having power changes in the range of a few milliwatts to several watts and having durations in the range of about one millisecond to no more than one second.

66. The memory of claim 60 wherein the gradual change includes steps having power changes in the range of a few milliwatts to several watts and having durations in the range of about one millisecond to no more than one second.

Serial No. 09/821,753

IX. Evidence Appendix

1. The Declaration of Andrew Bailey, Ph.D., including Exhibit 1, submitted to the Patent and Trademark Office June 9, 2006;

2. The Declaration of Andrew Bailey, Ph.D., submitted to the Patent and Trademark Office June 24, 2007;

3. The Declaration of Thomas Kamp, submitted to the Patent and Trademark Office June 24, 2007.

Evidence Document 1,

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JUN 09 2006

Docket No.: 2328-053 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:
Tuquiang NI et al.	: Confirmation No. 5171
U.S. Patent Application No. 09/821,753	: Group Art Unit: 1763
Filed: March 30, 2001	: Examiner: Luz L. ALEJANDRO

For: PLASMA PROCESSING METHOD AND APPARATUS WITH CONTROL OF PLASMA EXCITATION POWER

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF ANDREW D. BAILEY III, Ph.D.

I, Andrew D. Bailey III, Ph.D., hereby declare as follows:

1. Exhibit 1 is an accurate statement of my education, work experience, honors, publications, presentations and abstracts and issued United States Patents. As part of my work experience, I have worked closely with those of ordinary skill in the art relating to plasma processing of work pieces and have supervised many persons of ordinary skill in the art in the plasma processing of work pieces. As a result of my work experience, I am knowledgeable of those of ordinary skill in the art in the plasma processing of work pieces. I am also regarded by my peers as an expert in the technology relating to plasma processing of work pieces. Many of the publications listed in Exhibit 1 are publications in refereed journals, and as such, were subject to peer review prior to publication.

2. I have carefully read the referenced application as filed, the claims presently pending in the referenced application, the Office Action of March 9, 2006, and the Bhardwaj et al. reference, USP 6,051,503, primarily relied on in the Office Action.

3. My review of the referenced application, as originally filed, finds support for the requirement of claims 1 and 17 for "the AC etchant plasma always being the dominant material applied to the work piece while the feature is being formed."

(a) Page 5, lines 26-28 and claim 8, page 19 indicate that in the preferred embodiment, a gas species is ionized into a plasma that etches the material and that the preprogrammed gradual power change and the species are such that the material is shaped so a rounded corner is formed in the material as a result of the etching. This statement enables one of ordinary skill in the art to understand that the feature is the rounded corner. One of ordinary skill in the art would understand from the statement that an AC etchant plasma is always the dominant material applied to the work piece while the rounded corner is being formed.

(b) Page 6, lines 1 and 2 and claims 9 and 10, on page 19 of the application as filed, state that in one specific embodiment, the etching forms a trench wall including the rounded corner, which in one embodiment is at an intersection of a wall and a base of a trench. One of ordinary skill in the art would understand, from this statement, that an etchant is a dominant material that forms a trench wall including a rounded corner, which one of ordinary skill in the art would equate with a feature, particularly since page 6, lines 1-2 and claims 9 and 10 indicate the rounded corner is at an intersection of a wall and a base of a trench.

(c) Page 6, lines 26-29, of the application as filed indicates Figure 5 is a schematic diagram of a cross section of an illustrative semiconductor wafer prior to etching and Figure 6 is a schematic diagram of the wafer illustrated in Figure 5 after it has been etched in accordance with a specific embodiment of the invention. Such a statement would lead one of ordinary skill in the art to understand that the changes that occurred in transforming the structure of Figure 5 into the structure of Figure 6 was caused by etching being a dominant material applied to the wafer.

(d) Page 8, lines 20-23, in paragraph 30 of the application as filed, indicates there usually are several gas sources of different species, e.g., etchants, such as SF_6, CH_4, C_{12}

and HBr, dilutants such as Ar or He and O_2 as a passivation gas. One of ordinary skill in the art would interpret this to mean that a feature could be formed exclusively from the etchant gas which would be a dominant gas to form the material, or as a combination of the etchant gas, the dilutant gas and/or the oxygen passivation gas. Based on the other statements in the application as filed about etching occurring to form the trench walls and rounded corner, one of ordinary skill in the art would know that the etchant gases referred to at page 8, lines 20-23, were the dominant gases in the etching operations.

(e) Page 9, lines 16 and 17 indicates that an end point is detected of the process (either etching or deposition) that plasma 50 is performing on work piece 54. This statement would be interpreted by those of ordinary skill in the art as detecting the end of an etching process dominated by an etchant gas or the end of a deposition step dominated by a deposition gas, such as oxygen serving as a passivation gas.

(f) Page 14, line 28-page 15, line 2 indicates Figures 5 and 6 are respectively schematic drawings of an illustrative semiconductor structure prior to and subsequent to etching operations in accordance with one embodiment of the present invention. Such a statement would be interpreted by one of ordinary skill in the art as a transformation occurring from the structure of Figure 5 to the structure of Figure 6 as a result of an etchant gas being the dominant material applied to the semiconductor structure.

(g) Page 15, line 8-page 16, line 20 refers only to etching of the structure of Figure 5 to get slightly above the trench final base 214, as illustrated in Figure 6. Page 16, lines 20-23 indicate the final etch operation of silicon substrate 202 between point 212 and base 214 is performed in such a manner as to achieve rounded edges 216 between point 212 and base 214. This statement indicates to one or ordinary skill in the art that an etching operation, using an etchant gas as the dominant material, results in the production of rounded edge 216.

(h) Page 16, line 26-page 17, line 1 states microprocessor 201 has a memory system that performs the final etch operation for 15 seconds. During the 15 second final etch operation a suitable mixture of HBr/O_2 constantly flows from source 68 into

chamber 40. One of ordinary skill in the art would interpret such a statement to mean that the etchant HBr is dominant over the O_2 passivation gas because the memory system is stated to perform the final etch operation.

(i) Page 17, lines 4 and 5 indicates that after base 214 has been reached, the etchant gases are purged from the chamber. Such a statement would lead one of ordinary skill in the art to assume that the etchant gases were the dominant gases applied during the formation of the features involved in etching the structure of Figure 5 into the structure of Figure 6.

4. I do not agree with the statement in the Office Action that Bhardwaj et al. discloses converting a gas species into an AC etchant plasma that is either the dominant material or the only material that is continuously applied to a work piece while a feature of the work piece is being formed. The Office Action erroneously states that a portion of the side wall of a trench can be considered as an exemplary feature.

(a) Each of independent claims 1, 29, 30 and 31 of Bhardwaj et al. is concerned with a method of etching a feature in a semiconductor substrate. To form the feature, the substrate is subjected to a cyclical process including plural successive process cycles. Each of the successive process cycles includes a first process of reactive ion etching and a second process of depositing a passivation layer by chemical vapor deposition.. Column 1, lines 4-13, of Bhardwaj et al. indicates that one possible feature is a trench wall, not a portion of the side wall of a trench.

(b) Based on the foregoing, it is clear to me, as an expert in the technology,.that Bhardwaj et al. does not disclose converting a gas species into an AC etchant plasma that is either the dominant or only material that is continuously applied to a work piece while a feature of the work piece is being formed. The entire thrust of the Bhardwaj et al. patent is to form a feature by alternately etching and depositing materials, as indicated, for example, by the waveforms of Figure 7, wherein the first, fourth and seventh columns are associated with etching, the second and fifth columns are associated with deposition, and the third and sixth columns are associated with pump out of gases. Figure 7 indicates

that during the etch steps, the coil power and the bias power remain constant and that the coil and bias power also remain constant during the etch steps. The waveforms of Figure 9(i) and 9(ii) indicate that bias power changes abruptly between the etch and deposition steps. The RF bias is high during the deposition steps when pressure is low, and is low during the etch steps, when pressure is high. Column 9, lines 47-51 indicates the bias changes from low to high as the cycle changes from deposition as etch, respectively, in synchronism with pressure changes from low to high. These alternate etch and deposition steps occur during etching of a feature, particularly a side wall, as discussed in column 1, lines 4-13 and as set forth in the independent claims.

(c) The discussion in Bhardwaj et al., column 8, line 27-column 9, line 34 indicates the importance Bhardwaj et al. ascribed to the alternate etching and deposition steps to form a feature. This portion of Bhardwaj et al. indicates the problems associated with the prior art, as represented by Figure 3, in forming a silicon trench only by etching. The paragraph bridging columns 8 and 9 is particularly relevant because it discusses the importance of the passivation, i.e., deposition, step.

(d) Based on the foregoing, Bhardwaj et al. does not form a feature of a work piece by converting a gas species into an AC etchant plasma that is always the dominant material applied to the work piece while the feature is being formed, wherein the amount of AC power applied to the plasma during etching of the work piece to form the feature gradually changes and a gradual transition in the shape of the material in the work piece being processed occurs in response to the gradual power change that occurs during the gradual transition in the shape of the material. While Bhardwaj et al. discloses gradual power change, the gradual power change is always associated with alternate application of etchant gas and deposition gas to the work piece during formation of the feature.

(e) In addition, Bhardwaj et al. does not form a feature of a work piece by converting a gas species into an AC etchant plasma that is always the dominant material applied to the work piece, wherein the amount of AC power applied to the plasma during etching of the work piece gradually changes and a gradual transition in the shape of the

U.S. Patent Application No. 09/821,753 Attorney Docket No. 2328-053

material in the work piece being processed occurs in response to the gradual power change that occurs during the gradual transition in the shape of the material.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine, or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

DATED this 5 day of June, 2006, at Fremont CA.

Andrew D. Bailey III, Ph.D.

EXHIBIT I – ANDREW D. BAILEY III, PH.D. DECLARATION

Lam Research Corporation
4650 Cushing Parkway CA-3
Fremont, CA 94538-6470
(510) 572 - 2200
andrew.bailey@lamrc.com

5167 Northway Road
Pleasanton, CA94566
(925) 461 - 8642

Education

Ph.D. Applied Physics 2/93
Experimental Plasma Physics
California Institute of Technology, Pasadena
Thesis Research: Used planar laser induced fluorescence to measure drift wave ion velocity field in a tokamak plasma and addressed relationship between stochastic particle trajectories and velocity distribution functions.
Advisors: Dr. Paul M. Bellan with Dr. Raul A. Stern (U. of Col. - Boulder)
B.S. Applied Mathematics, Engineering and Physics with Honors 5/87
University of Wisconsin - Madison GPA 3.9/4.0 Phi Beta Kappa

Experience

Technical Director 8/00 to present
Process Technology, New Product Development
Lam Research Corporation,
Fremont, CA

Responsible for managing the Plasma Process Technology engineering group for a number of Lam's emerging plasma processing products including hardware and applications on advanced plasma processing materials and integration flows internally, with industry partners and customers, e.g., 300mm Cu dual damascene, porous low-dielectric constant material, SiLK, organosilicate glass (OSG) etching, hi-dielectric constant material gate applications, magnetic random access memory (MRAM). Sponsor research activities in array multidisciplinary areas to support advanced capabilities: multivariate data analysis, university programs, rf technology and design.

Also responsible for process development on dual frequency confined (DFC) technology used in Lam 2300 Exelan 200/300mm plasma processors sold to leading semiconductor companies worldwide.

EXHIBIT 1 – ANDREW D. BAILEY III, PH.D. DECLARATION

Program Manager New Product Dev. 2/98 to 8/00
Lam Research, Fremont, CA
Built group of 8 process engineers working on range of new products and programs: ADP, patents, novel documentation strategies, dielectric etch, low-dielectric, Joint Product Development Programs 300mm dual damascene

Director Process Development 9/97 to 2/98
Trikon Technologies, Chatsworth, CA
Responsible for all demonstration activity, eleven etch tools (21 modules), lab, supervised 14 engineering personnel during turbulent corporate period.

300mm Etch Program Manager 8/97 to 2/98
Trikon Technologies, Chatsworth, CA
Plan Trikon's 300mm etch program. Responsible for product development, engineering, process transfer, marketing, Supervise development team and form engineering team to design 300mm module. Work with outside suppliers of critical components. Manage group of people including a Ph.D., engineer personnel and those involved in planning and marketing.

MØRI Metal Etch Product Manager 1/97 to 7/97
Trikon Technologies, Chatsworth, CA (merger PMT and Electrotech)
Supervised 5 people and was responsible for field process during tool startup, demonstrations, presentations, field process support, development of hardware and software and integration of new Anti-Corrosion Module, manage improvement of vapor delivery system for production. Managed a number of engineering projects in response to field requirements. Coordinated testing and improvement of electrostatic chuck for use at cryogenic temperatures. Brought performance of vapor delivery system to production, handed off manufacturing engineering. Managed integration of Electrotech high pressure module into Renaissance platform including software, mechanical and electrical systems as well as detailed process characterization.

Metal Etch Process Manager 1/96 to 1/97
Plasma and Materials Technologies
Managed formation and growth of Metal Etch Development Group involving plasma etching. Responsible for customer demonstrations, development of Tungsten interconnect etch process. Support introduction of Al and Tungsten etch tools into production. Managed Al etch process development team having three dedicated engineers. Transferred Al etch process to new Pinnacle 8000R platform.

EXHIBIT 1 – ANDREW D. BAILEY III, PH.D. DECLARATION

Member of Technical Staff 8/94 to 1/96
PMT, Research and Development

Developed Al etch process for PMT's MØRI helicon plasma source. Demonstrated superior Al to photoresist selectivity using $Cl_2/BCl_3/N_2$ etch processes on 6 and 8" wafers using Pinnacle 8000 cluster tool with MØRI helicon plasma source. Instrumental in sales to key customers in Korea (LGS, Hyundai) and Japan (Sharp). Improved data analysis software for Langmuir probe product. Demonstrated hydrogenation of poly-silicon TFT gates (Xerox). Studied strip and corrosion issues, LLS with Gary Selwyn

Postdoctoral Member of Technical Staff 3/93 to 8/94
Display Research Department — Dr. Richard A. Gottscho
AT&T Bell Laboratories, Murray Hill — Department Head

Studied low temperature silicon nitride deposition and subsequent processes for active matrix liquid crystal displays on plastic substrates. Used *in situ*, real time, attenuated total reflection Fourier transform infrared spectroscopy to study film and interface properties of SiN_x and other semiconductors. Studied aspect ratio dependent scaling of Si and GaAs trench etch rates in an ECR plasma reactor. Included etch inhibitor in ion-neutral synergy model to quantitatively describe data at different substrate temperatures. Supervised undergraduate summer intern.

Research Assistant 9/87 – 2/93
U.S. Dept. of Energy Magnetic Fusion Science Fellow 9/87 – 9/90
California Institute of Technology, Pasadena

Developed first plasma planar laser induced fluorescence diagnostic. Made first two-dimensional images of the plasma ion fluid velocity field. Found qualitative agreement between measured flow field of stochastically heated ions in a drift wave and calculations of the two-fluid drift approximation. Observed ion temperature oscillations coherent with the drift wave. Developed new theoretical viewpoint to study the effect of stochastic single particle dynamics on macroscopic plasma parameters.

Research Assistant Summer 1989
Los Alamos National Laboratory, NM

Wrote software for quantitative analysis of film images from soft x-ray pinhole camera on FRX-C/LSM field reversed configuration. Developed upgrade of x-ray camera to capture images directly with CCD camera for real time analysis of FRX plasma discharges. Collaborated with Dr. Dan Taggart under group leader Dr. R. B. Siemon.

Research Assistant 5/86 – 9/87
University of Wisconsin, Madison
Studied plasma wakes and double layers in Dr. Noah Hershkowitz's lab.

Freelance Programmer summers/vacations 4/82 – 6/85
Programmed math and science educational software for Control Data and Addison-Wesley

<u>Teaching Experience</u>

AT&T Mentor Program '93

AT&T Bell Laboratories
Taught semiconductor processing and ATR-FTIR to an undergraduate researcher while guiding her research project in our lab.

Summer Undergraduate Research Fellowship Supervisor '90 – '92
California Institute of Technology
Guided progress of three undergraduates during their research projects in our lab.

Teaching Assistant 9/91 – 6/92
California Institute of Technology
Lectured and graded homework for graduate plasma physics course.

Teacher 9/89 – 5/90
Caltech's Secondary Schools Science Project
Taught optics course to advanced high school students.

Technical Experience

Software — developed systems of programs for experimental control (custom and CAMAC), for data acquisition, analysis and display, for physical, dynamic and optical modeling, for digital image processing and for science education

Lasers — operated and maintained copper vapor, doubled Nd-YAG and dye lasers; built flashlamp pumped dye laser

Optics — designed novel low f/# imaging system with multianode microchannel plate photomultiplier; set up and used variety of optical systems: x-ray pinhole camera, optical multichannel analyzer, spectrometer, scanning etalon, interferometer, CCD camera, photomultiplier, electro-optic modulator, photodiodes

Electronics — built TTL timing and control circuits, analog detection circuits, dc and gated high voltage circuits; maintained pulsed power systems

Other Skills — used and maintained UHV and standard vacuum systems; experienced with machine shop skills; proficient with $\mathrm{T_EX}$, DesignCAD, Windows, Word, Origin, Excel, Project, Powerpoint

Honors

Lam Vista Award	7/04
Athletic Board Scholar (top GPA of all graduating varsity athletes at UW-Madison)	6/87
Trewartha Honors Undergraduate Research Grant	'86 – '87
Prof. Linnaeus Wayland Dowling Scholarship (math)	'85 – '87
Irma L. Newman Scholarship (math)	'85 – '86
Undergraduate Summer Institute (Livermore Natl. Lab., Hertz Fndtn., UC-Davis)	8/86

Publications

G. Tynan, A. D. Bailey III, G.A. Campbell, R. Charatan, A. de Chambrier, G. Gibson, D. J. Hemker, K. Jones, A. Kuthi, C. Lee, T. Shoji, M. Wilcoxson, "Characterization of an azimuthally symmetric helicon wave high density plasma source," J. Vac. Sci. Technol. A **15**(6), 1-8 (1997).

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EXHIBIT 1 – ANDREW D. BAILEY III, PH.D. DECLARATION

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A. D. Bailey, III, N. Hershkowitz, "Three Step Double Layers in the Laboratory," Geophy. Res. Lett. 15, 99 – 102 (1988).

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D. Diebold, N. Hershkowitz, T. Intrator, A. Bailey, "Self-similar potential in the near wake," Phys. Fluids 30, 579 (1987).

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N. T. Mittadar, M. Nikolaou, P. Yadav, A.D. Bailey III, D.J. Economou, "A hybrid approach to the design of experiments for efficient determination of optimal etch uniformity conditions," AIChE Annual Meeting, November 2004.

EXHIBIT 1 – ANDREW D. BAILEY III, PH.D. DECLARATION

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S.P. Lohokare, M. Kennard, A.D. Bailey III, and D. Hemker, "Challenges in Plasma Etching of Low Volatility Materials for Advanced Memory Applications," presentation at Sixth International Symposium on Sputtering and Plasma Processing (ISSP), June 2001.

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A. D. Bailey, III, J. A. Gregus, K. Krisch, P. Mulgrew, T. Polewik, and R. A. Gottscho "Low temperature silicon nitride deposition," talk given at Materials Research Society Flat Panel Desplay Materials Symposium, April 1994.

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D. P. Taggart, R. J. Gribble and A. D. Bailey, III, "End-on soft x-ray imaging of FRCs on the FRX-C/LSM experiment,'' Bull. Am. Phys. Soc. 34, 2124 (1989).

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D. Diebold, N. Hershkowitz, A. D. Bailey, III, M. Cho and T. Intrator, "Emissive probe vacuum potential measurements – the vacuum current bias method,'' Bull. Am. Phys. Soc. 32, 1872 (1987).

Patents

1. Temperature control system for plasma processing apparatus, US6,302,966, Oct01.
2. Method and apparatus for controlling the volume of a plasma – magnetic plasma screens, US6,322,661, Nov01.
3. Plasma processing systems – B field uniformity control, US6,341,574, Jan02.
4. Method and apparatus for producing uniform process rates – antenna and sandwich coupling window, US6,320,320, Nov02.
5. Antenna designs compensating for missing elements in real antennas, US6,518,705 Feb03.

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6. Method and apparatus for producing uniform process rates – specific antenna design, US6,653,791, Nov03.
7. Method for quantifying uniformity patterns and including expert knowledge for tool development and control – multivariate uniformity metric, US6,723,574, Dec02.
8. A Method for Designing Antennas for Inductive Coupling Which Minimize Azimuthal Asymmetry, US6,744,213 May02.
9. System, method and apparatus for improved global dual-damascene planarization, US6,821,899 Nov04.
10. RF Plasma stability improvement, US6,838,832 Jan05.
11. Passive coils for plasma processing uniformity improvement, US6,842,147 Jan05.
12. Method for producing a semiconductor device - specific DCH antenna design US6,873,112, Mar05.
13. Method for quantifying Uniformity Patterns for Tool Development and Monitoring – Mass Analogy, US6,922,603, Jul05.
14. System, method and apparatus for improved global dual-damascene planarization (uniformity compensation focus), US6,939,796, Sept05.
15. Small Volume Plasma Process Chamber with Hot Inner Surfaces, US7,009,281, Mar06.
16. Plasma In-Situ Treatment of Chemically Amplified Resist, US7,022,611, Apr06.

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Evidence Document 2

Docket No.: 2328-053

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

Tuquiang NI et al.

U.S. Patent Application No. 09/821,753

Filed: March 30, 2001

Confirmation No. 5171

Group Art Unit: 1763

Examiner: Luz L. ALEJANDRO

For: PLASMA PROCESSING METHOD AND APPARATUS WITH CONTROL OF PLASMA EXCITATION POWER

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF ANDREW D. BAILEY III, Ph.D.

I, Andrew D. Bailey III, Ph.D., hereby declare as follows:

1. Exhibit 1, submitted with my Declaration filed in the U.S. Patent and Trademark Office on June 9, 2006, is an accurate statement of my education, work experience, honors, publications, presentations and abstracts and issued United States Patents. As part of my work experience, I have worked closely with those of ordinary skill in the art relating to plasma processing of workpieces and have supervised many persons of ordinary skill in the art in the plasma processing of workpieces. As a result of my work experience, I am knowledgeable of those of ordinary skill in the art in the plasma processing of workpieces. I am also regarded by my peers as an expert in the technology relating to plasma processing of workpieces. Many of the publications listed in Exhibit 1 are publications in refereed journals, and as such, were subject to peer review prior to publication.

2. I have carefully read the referenced application as filed, the claims I understand attorney for applicants plans to submit with this Declaration in the referenced application,

the Office Action of March 9, 2006, and the Bhardwaj et al. reference, USP 6,051,503, primarily relied on in the Office Action.

3. My review of the referenced application, as originally filed, finds support for the requirement of claims 46 and 58 for "the AC etchant plasma always being the dominant material applied to the workpiece while the desired shape is being formed."

(a) Page 5, lines 26-28 and claim 8, page 19 indicate that, in the preferred embodiment, a gas species is ionized into a plasma that etches the material and that the preprogrammed gradual power change and the species are such that the material is shaped so a rounded corner is formed in the material as a result of the etching. This statement enables one of ordinary skill in the art to understand that in one embodiment the desired shape is the rounded corner. One of ordinary skill in the art would understand from the statement that an AC etchant plasma is always the dominant material applied to the workpiece while the rounded corner is being formed. Otherwise, etching of the workpiece to obtain the rounded corner would not have occurred. One of ordinary skill would understand that if an etchant gas were not always dominant, e.g., if a passivation gas or a dilutant gas were dominant, the rounded corner of Fig. 6 could not have been formed.

(b) Page 16, line 23-page 17, line 2 states microprocessor 201 has a memory system that performs the final etch operation for 15 seconds. The final etch operation causes formation of a predetermined shape, e.g., a rounded edge 216 between point 212 and base 214. During the 15 second final etch operation a suitable mixture of HBr/O_2 constantly flows from source 68 into chamber 40 while the power that amplifier 132 supplies to electrode 56 gradually changes from 200 watts to 100 watts. One of ordinary skill in the art would interpret such a statement to mean that the etchant HBr is always dominant over the O_2 passivation gas during the 15 second etch operation. One of ordinary skill in the art knows that if the etchant gas HBr and the passivation gas O_2 both constantly flow to a chamber to perform an etch operation, that the etchant gas HBr must always be dominant over the passivation gas O_2 during that etching operation. Otherwise,

material in the passivation gas would be deposited on the workpiece and would have a greater effect on the material being worked than the etchant gas. As a result, the rounded corner, i.e., edge, illustrated in Fig. 6 would not have been formed.

4. I do not agree with the statement in the March 9, 2006, Office Action that Bhardwaj et al. discloses converting a gas species into an AC etchant plasma that is either the dominant material or the only material that is continuously applied to a workpiece while a feature of the workpiece is being formed.

(a) The specification and each of independent claims 1, 29, 30 and 31 of Bhardwaj et al. are concerned with a method of forming a feature in a semiconductor substrate. To form the feature, the substrate is subjected to a cyclical process including plural successive process cycles. Each of the successive process cycles includes a first process of reactive ion etching and a second process of depositing a passivation layer by chemical vapor deposition.

(b) Based on the foregoing, it is clear to me, as an expert in the technology, that Bhardwaj et al. does not disclose converting a gas species into an AC etchant plasma that is either the dominant or only material that is continuously applied to a workpiece while a desired shape in the workpiece is being formed. The entire thrust of the Bhardwaj et al. patent is to form a feature, e.g., a trench, by alternately etching and depositing materials, as indicated, for example, by the waveforms of Figure 7, wherein the first, fourth and seventh columns are associated with etching, the second and fifth columns are associated with deposition, and the third and sixth columns are associated with pump out of gases. Figure 7 indicates that during the etch steps, the coil power and the bias power remain constant and that the coil and bias power also remain constant during the deposition steps. The waveforms of Figure 9(i) and 9(ii) indicate bias power changes abruptly between the etch and deposition steps. The RF bias is high during the deposition steps when pressure is low, and is low during the etch steps, when pressure is high. Column 9, lines 47-51 indicates the bias changes from low to high as the cycle changes from deposition to etch, respectively, in synchronism with pressure changes from low to high. These alternate

etch and deposition steps occur during formation of a feature, particularly a trench wall, as discussed in column 1, lines 4-13 and as set forth in Bhardwaj et al.'s independent claims.

(c) The discussion in Bhardwaj et al., column 8, line 27-column 9, line 34 indicates the importance Bhardwaj et al. ascribed to the alternate etching and deposition steps to form a feature. This portion of Bhardwaj et al. indicates the problems associated with the prior art, as represented by Figure 3, in forming a silicon trench only by etching. The paragraph bridging columns 8 and 9 is particularly relevant because it discusses the importance of the passivation, i.e., deposition, step.

(d) Based on the foregoing, Bhardwaj et al. does not form a desired shape of a workpiece by converting a gas species into an AC etchant plasma that is always the dominant material applied to the workpiece while the desired shape is being formed, wherein the amount of AC power applied to the plasma during etching of the workpiece to form the desired shape gradually changes and a gradual transition in the shape of the material in the workpiece being processed occurs in response to the gradual power change that occurs during the gradual transition in the shape of the material. While Bhardwaj et al. discloses gradual power change, the gradual power change is always associated with alternate application of etchant gas and deposition gas to the workpiece during formation of the feature, e.g., a trench.

(e) In addition, Bhardwaj et al. does not form a desired shape of a workpiece by converting a gas species into an AC etchant plasma that is always the dominant material applied to the workpiece, wherein the amount of AC power applied to the plasma during etching of the workpiece to form the desired shape gradually changes and a gradual transition in the shape of the material in the workpiece being processed occurs in response to the gradual power change that occurs during the gradual transition in the shape of the material.

5. An unobviousness aspect of the present invention over Bhardwaj et al. is that desired shapes can be formed by gradually changing plasma power without changing the gas species in the plasma. In Bhardwaj et al., the species are repeatedly changed from an etchant gas to a passivation gas during formation of a desired shape, e.g., walls of a trench. The present application, on page 3, lines 3-28, indicates the advantages of maintaining species constant while a desired shape is being formed. By practicing the method of the present invention, the problems of the prior art that Bhardwaj et al. were trying to overcome are avoided. This is because a true rounded corner is initially formed to prevent formation of the notches of Fig. 13, as described in column 8, lines 27-43. In addition, the method of the present invention is more efficient, more effectively controlled and is simpler to execute than the Bhardwaj et al. process because there is no need to switch between passivation and etchant gases.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine, or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

DATED this 17 day of May, 2007, at 18:30 Fremont, CA

Andrew D. Bailey III, Ph.D.

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Docket No.: 2328-053

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	
Tuqiang NI *et al.*	Confirmation No. 5171
U.S. Patent Application No. 09/821,753	Group Art Unit: 1763
Filed: March 30, 2001	Examiner: Alejandro Mulero, Luz L.

For: PLASMA PROCESSING METHOD AND APPARATUS WITH CONTROL OF PLASMA EXCITATION POWER

DECLARATION UNDER 37 CFR 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Thomas A. Kamp, hereby declare as follows:

[0001] In 2000, I earned, from San Jose State University, a Master of Science Degree (MSE) In Materials of Electronic Devices. My masters degree thesis was entitled "PECVD Undoped Silicon Glass Film in 300 Millimeter Wafers." In 1995, I earned, from San Jose State University, a Bachelor of Science Degree (BS) in Materials Science.

[0002] Between 1995 and 2000 I worked for Mattson Technologies on machines for manufacturing semiconductor equipment, particularly machines relating to deposition and stripping of materials on semiconductor wafers.

Between 2000 and the present time, I have been employed by Lam Research Corporation, the assignee of the referenced application, in connection with the development of machines for manufacturing semiconductor equipment, including aspects of such machines for forming features, such as trenches, vias, comers, contacts and lines, on semiconductor wafers. My current title is Senior Staff Process Engineer.

[0003] I am one of the patentees of the following four United States Patents:

7,186,661, entitled "Method to Improve Profile Control and N/P Loading in Dual Doped Gate Applications" (attached Exhibit 2);

7, 098, 141, entitled "Use of Silicon Containing Gas for CD and Profile Feature Enhancements of Gate and Shallow Trench Structures" (attached Exhibit 3);

6, 939, 811, entitled "Apparatus and Method for Controlling Edge Depth" (attached Exhibit 4); and

6, 921, 724, entitled "Variable Temperature Processes for Tunable Electrostatic Chuck" (attached Exhibit 5).

All of these patents are concerned, to at least a certain extent, with forming features, including trenches, in semiconductor wafers.

[0004] During my employment with Lam Research Corporation I have personal knowledge of rounded comers of trenches of workpieces, in the form of

silicon wafers, being formed in a vacuum plasma chamber. The rounded corners were formed by converting a gas species that was supplied to the chamber into an etchant plasma that was continuously applied to the workpiece while the rounded corners were being formed. While the rounded corners were being formed, the power applied to the etchant plasma was gradually changed. The gradual power change was such that the power did not remain constant for durations in excess of one second while the rounded corners were being formed. While the rounded corners were being formed, in first instances, the following parameters were maintained constant: (1) pressure in the chamber, (2) flow rate of the gas species into the chamber, and (3) species flowing into the chamber. While the rounded corners were being formed in second instances, plasma power was gradually changed as indicated above, and pressure in the chamber was gradually changed while the flow rate of the gas species into the chamber and the species flowing into the chamber were maintained constant. Microphotographs of the rounded corners thus formed in both the first and second instances indicated the rounded corners were smooth without any sign of damaged edges. The smooth rounded corners were formed in both the first and second instances without the necessity for a soft etch being applied after the corners were formed.

[0005] I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that the statements were made with the knowledge that willful false statements and the like so made are punishable by fine, or imprisonment,

or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Dated this 9 day of May, 2007, at Fremont, California.

Thomas A. Kamp

X. Related Proceedings Appendix

None.